

# SCHOLARSHIPS OR STUDENT LOANS? SUBSIDIZING HIGHER EDUCATION IN THE PRESENCE OF MORAL HAZARD

ALESSANDRO CIGNO  
ANNALISA LUPORINI

CESIFO WORKING PAPER NO. 973  
CATEGORY 1: PUBLIC FINANCE  
JUNE 2003

PRESENTED AT CESIFO AREA CONFERENCE ON PUBLIC SECTOR ECONOMICS, MAY 2003

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# SCHOLARSHIPS OR STUDENT LOANS? SUBSIDIZING HIGHER EDUCATION IN THE PRESENCE OF MORAL HAZARD

## Abstract

Student loans, even income-contingent ones, are not optimal. Potential university students with the appropriate characteristics should be offered a scholarship, dependent on both need and merit. The award of the scholarship should be conditional on the choice of university degree, but students with a natural aptitude for studies that do not hold the prospect of a well paid job should not be pushed towards potentially more lucrative ones. The scheme should be financed by a graduate tax that re-distributes from the better paid to the academically more successful.

JEL Code: D82, I28.

Keywords: scholarships, student loans, graduate tax, principal-agent, moral hazard.

*Alessandro Cigno*  
*Dipartimento di Studi sullo Stato*  
*Università di Firenze*  
*Via S. Caterina d'Alessandria 3*  
*50129 Firenze*  
*Italy*  
*cigno@unifi.it*

*Annalisa Luporini*  
*Dipartimento di Scienze Economiche*  
*Università di Firenze*  
*Via Curtatone 1*  
*50123 Firenze*  
*Italy*  
*luporini@cce.unifi.it*

## 1 Introduction

Whether and in which way the government should help students pay for a higher education is a matter of great practical and theoretical interest. Yet, there is remarkably little analytical work on the subject.<sup>1</sup> In the presence of full contingent markets allowing potential students to discount expected future incomes, and assuming no external effects of university education, there would be no reason for public concern (distributional considerations could be dealt with separately from education). Since markets are incomplete, however, the young have difficulty in borrowing against expected future incomes (Stiglitz and Weiss, 1981), and insuring against the risks associated with educational investment. In the absence of policy, a young person's ability to attend university would thus be restricted by the extent to which his parents are able to support him. It is then possible that a number of young people, who could gain from attending university, will not do so. There is thus an argument for relaxing the budget constraint of these young people, and possibly insuring them against the risk of a poor outcome at university or, later, in the market place.

Public intervention may be justified also by an externality argument. If part of the benefit of a university education accrues to society as a whole, rather than to the person being educated, the cost should not fall entirely on the latter. One such effect arises from the existence of a government budget constraint. Since graduates earn more, on average, than non graduates, an increase in the number of graduates will expand the tax base, and thus benefit all, including non graduates. Additional externalities arise if a university education increases the productivity, not only of the graduate himself, but also of those who will work with him, or if university graduates raise the cultural level of a country for the benefit of all. However, such additional external benefits may be offset by the external costs if a university education makes the graduate dissatisfied with intellectually unchallenging (but nonetheless useful) jobs, or if cultured citizens attract the antipathy of uncultured ones.<sup>2</sup>

The basic policy question is whether the government should use its

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<sup>1</sup>The importance of education for economic growth is well documented; see, for example, Jorgenson and Fraumeni (1992). A good theory-based discussion of different policy proposals regarding the financing of higher education students is in Barr (1991). We are not aware of any formal analysis of whether students should be financed by means of a loan or of a scholarship, and on what conditions.

<sup>2</sup>Especially if the former exercise undue weight over the destination of public expenditure. The usual example given is that of the educated middle classes pushing for public subsidies to art galleries and opera houses, of which they themselves are overwhelmingly the patrons.

superior financial position to help young people with an aptitude for higher education realize their potential. Subsidiary policy questions concern the precise form of the intervention. We hypothesize an institutional setting where school education is sufficiently subsidized, and the school curriculum sufficiently broad, to allow every young person to reveal both his aptitude for a university education, and his natural predisposition towards the study of one or another subject. For simplicity, we also assume that the net effect of allowing an extra person to go to university on the welfare of those who will not (but not necessarily on the welfare of other graduates) is negligible. This last assumption allows us to restrict the analysis to those young people who would profit from a university education in the precise sense that, given full contingent markets, they would have gone to university even without public help. If the number of graduates has a positive effect on the welfare of non graduates, that will only strengthen the argument for a policy that facilitates access to university, and justify financing this policy in part with a levy on the whole population, without necessarily changing the characteristics of the optimal policy in other respects.

As school records are available to the policy maker, there is no problem of hidden personal characteristics. There is, however, a hidden action problem in that the amount of effort a student puts into his higher education is private information. One of the subsidiary questions we shall ask is then how to help students financially, without weakening their incentive to study hard. Another question arises from the fact that certain university subjects have a higher expected return, in terms of post-graduation income, than others. In what follows, we shall talk of "science" referring to subjects that hold the prospect of a well paid job, of "arts" referring to less profitable subjects, but that is just short-hand (for present purposes, science includes accountancy, arts includes pure economics). The question is whether students with a natural predisposition for the arts should be allowed to follow their natural inclination, or pushed towards science. Yet another question concerns the allocation of risk. Given that university grades, and the level of income after graduation, depend partly on luck, should the policy include some element of insurance?

A possible solution to the policy problem is a loan guarantee. Loans give students every possible incentive to do well in their studies. However, they distort choice towards subjects with a high earning potential, and discriminate against students from poor families. Both these drawbacks are mitigated if the re-payment is contingent on realized income.<sup>3</sup> An alternative is a scholarship scheme. Scholarships do not dis-

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<sup>3</sup>The idea of income-contingent loans comes originally from Blaug; see Barr (1991).

tort choice, and do not discriminate against students from poor families. However, they give rise to moral hazard, as students (particularly arts students, whose opportunity-cost in terms of expected future income is comparatively small) may choose to have a good time instead of studying hard. Furthermore, a scholarship scheme ...nanced by general taxation is generally thought to be regressive, because graduates earn, on average, more than non graduates.<sup>4</sup> This shortcoming is avoided if scholarships are ...nanced by a tax on graduates only. The latter should not take us far from the optimum if our assumption of negligible spill-over effects on non graduates is correct.

Our strategy will be to characterize an optimal transfer scheme whereby students receive money from, and graduates pay money to, an education authority. The characteristics of these payments at the optimum will reveal whether the optimal policy is a loan or a scholarship scheme. The policy optimization has the logical structure of an agency problem, with the education authority in the role of principal, and potential students in that of agents. We shall assume that the objective function of the principal is the sum of the objective functions of the agents, so that the interests of the former are not diametrically opposed to those of the latter.<sup>5</sup>

## 2 Agents

In the present context, an agent is someone who just ...nished school with sufficiently high grades to make him university material. University material means that, were this person able to trade in full contingent markets, he would be better-off going to university than straight into the labour market. Suppose there are only two types of agent, a (for "arty") and s (for "scientific"). We assume that the education authority has access to school records, and thus knows which potential students are of type a, and which are of type s. The analysis covers two periods: period 1, when an agent can be either a student or a young worker, and period 2, when he is either a graduate or a non-graduate worker.

Let  $e^j$  (belonging to the closed interval  $E = [\underline{e}; \bar{e}] \subset \mathbb{R}^+$ ) denote study effort by student  $j$ , and  $e$  the vector of efforts put in by the different

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<sup>4</sup>This point was made by Friedman (1962) and is supported by empirical research in Hansen and Weisbrod (1969). Since then, several empirical studies have addressed the question of the distributional impact of subsidies to higher education. Some papers support the "Friedman thesis", but most of them seem to ...nd that the impact is progressive. Nevertheless, conventional wisdom seems to favour the view that subsidies are regressive; see, e.g., the discussion in Barbaro (2002).

<sup>5</sup>A policy problem with a similar structure is in Cigno, Luporini and Pettini (2002). There, however, the role of agent is played by parents of young children, not by the children themselves, and the issues are quite different.

students.<sup>6</sup> Similarly, let  $d^j$  denote the type of degree chosen by student  $j$ , and  $d$  the vector of degree types chosen by all students. We characterize a degree by the proportion of science subjects included in it ( $d = 0$  if the curriculum consists entirely of arts subjects,  $d = 1$  if it includes only science subjects). Effort is not observable, but the choice of degree is.

The final degree result of student  $j$  is denoted by  $x^j$  (belonging to the closed interval  $X = [\underline{x}; \bar{x}] \subseteq \mathbb{R}$ ),<sup>7</sup> and those of all students by the vector  $x$ : Ex ante, degree results are distributed with joint density  $f(x; e)$ , assumed known.<sup>8</sup> Having assumed that the characteristics ( $a$  or  $s$ ) of each agent are also known, the uncertainty surrounding the realization of  $x^j$ , for any given  $e^j$ , is purely the effect of luck in university examinations. Studying harder does, however, make it more likely that a student will obtain high grades, in the precise sense that the cumulative distribution of  $x^j$  associated with a higher  $e^j$  stochastically dominates that associated with a lower  $e^j$ .

In period 1, agents decide whether to attend university or go straight into the labour market. If agent  $j$  chooses to be a student, he receives  $m_1^j + y^j$ . We may interpret  $m_1^j$  as parental support, and  $y^j$  as either a loan (guaranteed by the government) or a scholarship. The vector of parental support levels, and that of the scholarships or loans, received by the different students are respectively represented by  $m_1$  and  $y$ . If the agent chooses to go straight into the labour market, he earns  $w_1$  (all young workers earn the same). Both  $m_1$  and  $w_1$  are defined net of any general income tax. Both are certain, and known. In assuming this of  $m_1$ , we are in effect saying that, if a young person goes to university, his parents are somehow obliged to support him at some level (dependent on their means).<sup>9</sup> Were that not the case, parents would in fact be tempted

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<sup>6</sup>If there were only two students, one of each type, we could simply write  $e^a$  and  $e^s$ . Since there are many agents of the same type, however, we keep to the generic  $j$  index.

<sup>7</sup>In some university systems, there is an actual degree result. In others, we may think of the degree result as of the average of the grades obtained in individual exams.

<sup>8</sup>We assume that the monotone likelihood ratio (MLR) condition, namely that  $(\frac{f_{e^j}}{f})$  is increasing in  $x^j$ , holds with respect to agent  $j$ 's effort, and that the upper cumulative probabilities of  $x^j$  are nondecreasing and concave in  $e^j$ . These assumptions guarantee that the first order approach is valid in multi-signal principal-agent models (Sinclair-Desgagné, 1994). By ensuring uniqueness of the agent's choice of effort, they will allow us to substitute the first-order condition of the agent's problem for the incentive compatibility constraint in the principal's optimization problem (see section 3).

<sup>9</sup>That used to be the case, for example, in pre-Thatcher UK, where the grant awarded to a student admitted to university included a mandatory parental support element, calculated on the basis of parental income.

to free-ride.

In period 2, agent  $j$  gets  $w_2 + m_2^j + \zeta^j$  if he is a graduate,  $w_2$  if he is not. We interpret  $w_2$  as the earnings of a non-graduate adult worker (the same for everyone), and  $m_2^j$  as a skill premium. Depending on whether  $y^j$  is a loan or a scholarship,  $\zeta^j$  is either a loan re-payment or a graduate tax. All payments are discounted back to period 1 at the given rate of interest.<sup>10</sup> The vector of the skill premia earned by the different agents is denoted by  $m_2$ , that of the loan re-payments or graduate taxes by  $\zeta$ . Both  $w_2$  and  $m_2$  are net of any general income tax (raised by the government for purposes other than university education, and payable by everyone).

We assume that both  $m_2$  and  $w_2$  are observable ex post. While  $w_2$  is certain and known in advance, however,  $m_2$  is distributed ex ante with known joint density  $g(m_2; x; d)$ , conditional on degree types and degree results. The cumulative distribution of  $m_2^j$  associated with a higher  $d^j$  or  $x^j$  stochastically dominates that associated with a lower  $d^j$  or  $x^j$ . In other words, higher grades, or a degree with a higher science content, make it more likely that the graduate will get a high income in period 2. For any given  $d^j$  and  $x^j$ , the uncertainty surrounding the realization of  $m_2^j$  reflects  $j$ 's luck in finding a well paid job.

Let  $z^j(d^j; e^j)$  be the cost of studying the subject mix  $d^j$  for student  $j$ . This cost includes not only the actual expenses incurred, and the current income forgone, in attending university, but also the consumption equivalent of the disutility of study effort.<sup>11</sup> This disutility may well be negative for certain values of  $d^j$  and  $e^j$  (in other words, at least up to a certain effort level, studying the subjects of one's choice may be a pleasure). Even though the other cost components are necessarily positive,  $z^j$  may thus have any sign. To ensure convexity, we assume that the marginal cost of effort is positive and increasing for all students ( $z_{e^j} > 0$ ,  $z_{e^j e^j} > 0$ ). We also assume that, as the subject mix becomes more scientific, the cost of getting a degree increases for the a type, but not necessarily for the s one; in any case, it increases more for the former than for the latter (if  $j$  is an a, and  $k$  is an s,  $z_{d^j}^j > z_{d^k}^k$ ). Similarly, we assume that an increase in the science content of the degree raises the marginal cost of effort if the student has a natural disposition towards the arts, but not necessarily if he is predisposed towards the study of science; in any case, it raises it more for the former than for the latter (if  $j$  is an a, and  $k$  is an s,  $z_{e^j d^j}^j > z_{e^k d^k}^k$ ). The function  $z^j(\cdot)$  is known

<sup>10</sup>Recall that, although agents cannot borrow, the principal can. Expressing period-2 payments in period-1 money avoids carrying the discount factor around.

<sup>11</sup>We may similarly think of  $w_t$  as earnings net of the consumption-equivalent of the disutility of labour.

to all concerned.

Ex post, the lifetime utility of agent  $j$  is given by

$$U^j = u_1(c_1^j) + u_2(c_2^j); \quad (1)$$

where  $c_1^j$  is the consumption of agent  $j$  in period  $t$ . The functions  $u_t(\cdot)$  are assumed increasing and concave, with  $u_t'(0) = 1$ . In the absence of credit markets allowing young people to borrow against expected future income, agent  $j$  faces a separate budget constraint for each period. In the absence of insurance markets allowing him to insure against poor university results, his consumption in period 1 is then given by

$$c_1^j = m_1^j + y^j - z^j \quad (2)$$

if he goes to university, by

$$c_1^j = w_1 \quad (3)$$

if he does not. In the absence of insurance markets allowing him to insure against bad luck in the graduate labour market, his consumption in period 2 is

$$c_2^j = w_2 + m_2^j - \zeta^j \quad (4)$$

if  $j$  is a graduate,

$$c_2^j = w_2 \quad (5)$$

if he is not. Both  $y^j$  and  $\zeta^j$  may be functions of any of the observed variables. Thus,  $y^j$  may depend on  $m_1$ , and be conditional on the realization of  $x$ , while  $\zeta^j$  may depend on any of  $m_1$ ,  $m_2$ ,  $x$  and  $y$ .

For the generic agent ( $j$  index omitted), the pay-off to being a student, denoted by  $\frac{1}{4}^s(m_1; w_2; y; \zeta)$ ; is the value of his expected utility,

$$E(U) = \int_x u_1(c_1) f dx + \int_x \int_{m_2} u_2(c_2) g dm_2 f dx; \quad (6)$$

with  $c_1$  and  $c_2$  given by (2) and (4), maximized with respect to the agent's choice of  $e$  and  $d$ . The latter satisfies the first-order conditions

$$\int_x u_1'(c_1) z_e f dx + \int_x u_1'(c_1) f_e dx + \int_x \int_{m_2} u_2'(c_2) g dx dm_2 = 0 \quad (7)$$

and

$$\int_x u_1'(c_1) z_d f dx + \int_x \int_{m_2} u_2'(c_2) f g dx dm_2 = 0; \quad (8)$$

The pay-off to being a young worker, denoted by  $\frac{1}{4}(w_1; w_2; \zeta)$ , is the value of the agent's expected utility, with  $c_1$  and  $c_2$  determined by (3) and (5):



The agent will choose to be a student if and only if

$$V^s(m_1; w_2; y; \zeta) \geq V^l(w_1; w_2): \quad (9)$$

In other words, a person will not go to university if so doing would leave him worse-off than going straight into the labour market. Therefore, in the absence of public support, or if this were not sufficiently generous, a number of agents would not attend university. That would have a social cost because, by definition of agent, the expected gain from a university education is greater than the cost.

### 3 Principal

The principal is an education authority with the power to guarantee student loans, or to pay out scholarships financed by a debt issue, and recover the cost by raising education-specific taxes (a "graduate tax"). The authority chooses  $(e; d; y; \zeta)$  so as to maximize the sum of the expected utilities of the agents,

$$\sum_j \int_x \mu^s u_1^s c_1^j + \int_{m_2} \mu^l u_2^l c_2^j g dm_2 f dx; \quad (10)$$

subject to (2) - (5) for each  $j$ , and to a number of other restrictions.

Since the authority is ultimately responsible for the cost of  $y$ , irrespective of whether the elements of  $y$  are scholarships or guaranteed loans, a restriction on the education authority's choice of policy is the intertemporal budget constraint,

$$\sum_j \int_x \mu^s y^s i^s + \int_{m_2} \mu^l \zeta^l g dm_2^l f dx = 0; \quad (11)$$

where  $y^j$  and  $\zeta^j$  may be contingent on any of the observed variables. Writing this constraint in expected value terms implies that the principal faces no uncertainty about how much it will have to pay out in total to students in period 1, and how much it will get back in total from graduates in period 2. Therefore, the number of agents is "large". This could mean either that there are many students of each type, or that there are many types of student. Having assumed that there are only two types (a and s), there must then be many students of each type.

In addition to the intertemporal budget constraint, the principal faces two restrictions for each agent  $j$ : One is that the principal's choice of  $e^j$  must satisfy an incentive-compatibility constraint in the form of (7). There is no such restriction on the principal's choice of  $d^j$ , because the

subject mix is observable, and thus controllable.<sup>12</sup> The other is a participation constraint in the form of (9). If individual effort were observable by the education authority, neither of these additional restrictions would be binding for any of the agents. If individual effort is not observable, it can be shown, using standard techniques, that the incentive-compatibility constraints are binding. Since the same is not necessarily true of the participation constraints, however, we shall develop the argument assuming, at first, that none of these constraints is binding. Then, we shall see what happens if the assumption is relaxed.

The first-order condition on the principal's choice of  $y^j$  is

$$(u_1^0 - \lambda) f + \lambda^j \left[ u_1'' z_{ej}^j f + u_1^0 f_{ej} \right] = 0; \quad (12)$$

where  $\lambda$  is the Lagrange multiplier associated with the principal's budget constraint, and  $\lambda^j$  the Lagrange multiplier associated with the incentive compatibility constraint concerning  $j$ 's effort.

In first best ( $\lambda^j = 0$  for all  $j$ ), (12) reduces to  $u_1^0 = \lambda$ , implying that each agent must be guaranteed a certain  $c_1^j$ , irrespective of  $m_1^j$  and  $x^j$ . The first-best policy thus re-distributes from rich to poor students, and across states of nature. In other words, if effort were observable, it would be optimal for the authority to fully compensate students for any difference in the cost of getting a degree, or shortfall in the amount of support received from their parents. It would also be optimal to provide each student with full insurance against the risk of getting a poor degree result (or failing outright) in period 1. This "full insurance" result is standard in principal-agent models. In standard principal-agent models, however, it descends from the assumption that the principal is less risk-averse than the agent. Here, by contrast, the principal is as risk-averse as any of the agents, and the result descends from the fact that the principal does not face any financial risk.<sup>13</sup>

If individual effort is not observable, the principal must be content with second best. As  $\lambda^j$  is then positive, (12) may be re-written as

$$\frac{\lambda}{u_1^0} = 1 + \lambda^j \left[ r z_{ej}^j + \frac{f_{ej}(x; e)}{f(x; e)} \right]; \quad (13)$$

where

$$r = - \frac{u''}{u^0} \quad (14)$$

<sup>12</sup>It can be controlled by offering the agent a kind of contract ("forcing contract"): "if you choose the  $d^j$  I tell you, I shall pay you the optimal  $y^j$  now, and charge you the optimal  $z^j$  next period; if you do not, I shall pay you a lower (even zero)  $y^j$  now, or charge you a punitive  $z^j$  next period."

<sup>13</sup>The same occurs in Cigno, Luporini and Pettini (2002), which also has a principal maximizing the sum of the expected utilities of a large number of agents.

is the Arrow-Pratt measure of absolute risk aversion (assumed constant). Since the r.h.s. of (13) is increasing in  $x^j$ , and the l.h.s. increasing in  $c_1^j$ , the amount paid to the student,  $y^j$ , must be an increasing function of the student's degree result,  $x^j$ . It must also be higher for students with lower parental support,  $m_1^j$ , or higher cost of attending university,  $z^j$ . As in ...rst best, the policy will thus re-distribute in favour of students from poorer families, and of students who (because of their personal characteristics, or choice of subject mix) face a higher cost of education. Perfect equality will not be achieved, however, because students must now be given an incentive to study hard. The more costly it is to provide a certain type of student with this incentive, the more his choice of effort level will be distorted.

If the random variable affecting the degree result of student  $j$  (for any given level of effort) is stochastically independent of those affecting the degree results of other students, the second-best value of  $y^j$  does not depend on the results obtained by other students. Otherwise, the likelihood ratio  $\frac{f_{e^j}(x;e)}{f(x;e)}$  will be a function of the entire  $x$  vector (Holmström, 1982; Mookherjee, 1984). If that is the case, and if the random variables affecting degree results for any given level of effort are affiliated and dependent,<sup>14</sup> the second-best  $y^j$  is increasing in  $x^j$ , and decreasing in  $x^k$  ( $j \neq k$ )<sup>15</sup>. In other words, ranking matters. An implication is that grade drift should not fool the education authority into granting larger loans or higher scholarships to everybody.

The ...rst-order conditions on the principal's choice of  $d^j$  and  $e^j$  are long and unwieldy. We approach them one step at a time. Using (13), the conditions for a ...rst best may be written as

$$\int_{x^j} \int_{m_2^j} \left[ u_2 + \lambda^j \int_{e^j} f_{g_{d^j}} dx dm_2 \right] = \lambda^j z_{d^j}^j \quad (15)$$

and

$$\int_{x^j} \int_{m_2^j} \left[ u_2 + \lambda^j \int_{e^j} f_{e^j} g dx dm_2 \right] = \lambda^j z_{e^j}^j; \quad (16)$$

<sup>14</sup> Affiliation implies that the random variables tend to "move together". In other words, if variables are affiliated, it is more likely that their realized values will be all high, or all low, than that some will be high, and others low. Affiliation includes the case of independence. Since affiliated random variables have nonnegative covariance, affiliation can be seen as a form of positive correlation (provided that such covariance exists). Here, we consider the case of dependent affiliated random variables. For a formal discussion, see the Appendix.

<sup>15</sup> That  $y^j$  increases in  $x^j$  when  $\frac{f_{e^j}(x;e)}{f(x;e)}$  is monotone in  $x^j$  is a well known result (see, e.g., Mas-Colell, Whinston and Green, 1995). That  $y^j$  monotonically decreases in  $x^k$  when the random variables are affiliated is proved in Luporini (2002). A sketch of the proof is given in the Appendix.

where the l.h.s. is the expected effect of either  $d^j$  or  $e^j$  on the principal's optimization (the more science subjects agent  $j$  takes, or the harder he studies during period 1, the more he is expected to earn, and pay in taxes, during period 2). What does that tell us about the choice of effort and subject mix for agent  $j$ ?

Let us specialize the analysis a little by assuming that the cost of a university education increases with its science content for students with a natural disposition towards the arts, but decreases for those who are predisposed to the study of science ( $z_{di}^j$  positive or negative, depending on whether  $j$  is an  $a$  or an  $s$ ). Since a degree with a high science content pays, on average, more than a degree with a high arts content, an  $s$  will then study science subjects only ( $d^j = 1$ ). By contrast, an  $a$  will not necessarily study arts subjects only ( $d^j \leq 0$ ), because a lower  $d$  is associated with a lower expected  $m_2$ . Therefore, (15) holds for an  $a$ , but not for an  $s$ . The argument runs as follows.

If  $e^j$  were the same for both types, the r.h.s. of (16) would be higher for the  $a$ , than for the  $s$  type. We shall see below that  $z^j$  is generally higher for the latter. This, together with the fact that  $s$ -types earn more than  $a$ -types, implies that the l.h.s. would then be higher for the former, than for the latter. Therefore, in first best,  $e^j$  will be higher for the scientific than for the arty type. The same would be true if  $z_{di}^j$  were positive for students predisposed to the study of science (in which case, these students would not necessarily study science subjects only), but still increasing more slowly for this than for the other type of student as assumed.

We have thus found that, in first best, the arty type will not only take less science subjects, but also supply less effort, than the scientific type. Intuitively, that is because the expected return to investing in a university education is lower for the former than for the latter. Since the principal is maximizing the sum of the expected utilities (not the sum of the incomes, or abilities to pay tax) of the agents, it then follows that students with scientific talent should optimally invest more in their education (put in more effort, sacrifice more current consumption), than students with a natural disposition towards the arts.

In second best, the first-order condition on  $d^j$  may be written as

$$B^j_i - C^j + E^j = \int_0^1 D^j_i - F^j_i ; \quad (17)$$

where

$$C^j = \int_x^z u_1^0 z_d f dx$$

denotes the expected cost,

$$B^j = \int_x^z \int_{m_2} z u_2 f g_{di} dx dm_2$$

the expected private benefit, and

$$E^j = \int_{x_1}^{x_2} \int_{m_1}^{m_2} z_{dj}^j f_{gdj} dx dm_2$$

the expected external benefit (through the government budget constraint) of inducing agent  $j$  to take more science subjects. The term

$$D^j = \int_{x_1}^{x_2} [u_1'' z_{ej}^j z_{dj}^j f + u_1^0 z_{ej}^j f + u_1^0 z_{dj}^j f_{ej}] dx;$$

is the effect of a higher  $d^j$  on the expected marginal disutility of effort. It is thus the expected indirect effect on  $j$ 's period-1 utility of inducing this agent to take more science subjects. If both  $z_{dj}^j$  and  $z_{ej}^j$  are positive,  $D^j$  is clearly greater than zero. If  $z_{dj}^j$  and  $z_{ej}^j$  are positive for the  $a$  type, but negative for the  $s$  type,  $D^j$  is positive (and  $d^j = 1$  as in first best) for the former, but negative for the latter. The term

$$F^j = \int_{x_1}^{x_2} \int_{m_1}^{m_2} u_2 f_{ej} g_{dj} dx dm_2;$$

also positive, is the expected indirect effect on agent  $j$ 's period-2 utility of pushing agent  $j$  towards science.

If time-preference is sufficiently high,  $D^j + F^j$  is positive for  $a$ -type agents. As  $B^j + E^j$  must then be larger than  $C^j$ , this means that  $d^j$  will be lower than in first best for this type of agent. Therefore, the second-best scheme actually encourages students with an aptitude for the arts to specialize further in their preferred subjects than they would in first best. The intuitive explanation is that, as effort is not observable, and providing the agent with the right incentive is consequently costly, the principal makes it easier for the artsy student to get higher grades by reducing the science requirement. If  $z_{dj}^j$  and  $z_{ej}^j$  are negative for  $s$ -type students, agents of this type will be at a corner ( $d^j = 1$ ); if they are positive,  $d^j$  is lower than in first best for  $s$  types too. Otherwise, we cannot say whether  $d^j$  is higher or lower than in first best.

The condition on  $e^j$  is of difficult interpretation. Let

$$G^j = \int_{x_1}^{x_2} \int_{m_1}^{m_2} z_{ej}^j f_{gdj} dx dm_2 + \int_{x_1}^{x_2} y^j f_{ej} dx;$$

denote the net effect, which may be shown to be positive, of  $e^j$  on the principal's budget constraint.  $G^j$  is the sum of two partial effects. The first one,  $\int_{x_1}^{x_2} \int_{m_1}^{m_2} z_{ej}^j f_{gdj} dx dm_2$ , arises from the fact that, the harder agent  $j$  studies during period 1, the more he is likely to earn and thus, if  $z_{ej}^j$  is increasing in  $m_2$ , pay in taxes or loan re-payment during period 2. The second partial effect,  $\int_{x_1}^{x_2} y^j f_{ej} dx$ , tells us that, the harder  $j$

studies during period 1, the larger the scholarship or the loan that he gets during period 1. If we assume that the random components of the different elements of  $x$  are uncorrelated, the condition on  $e$  is that  $G^j$  must be equal to an unwieldy expression (not reported), positive for the agent's second-order conditions, representing the net effect of  $e^j$  on the incentive compatibility constraint for agent  $j$ . Under this assumption, we can say that the second-best choice of  $e^j$  is lower than in first best, but we cannot say whether it is still lower for the arts than for the science type (because it may cost the principal less to give the incentive to a, than to s types).<sup>16</sup> If the random components are correlated, the condition contains additional terms (representing cross-effects), that make it quite impossible to say anything about the second-best choice of  $e^j$ .

The first-order condition on the amount (loan re-payment or graduate tax) that agent  $j$  must pay in period 2,  $z^j$ , is

$$u_2^0 + m_2^j z^j - u_2^0 f_{e^j} = 0; \quad (18)$$

which may also be written as

$$\frac{u_2^0}{u_2^0 + m_2^j z^j} = 1 + \frac{f_{e^j}(x; e)}{f(x; e)}; \quad (19)$$

In first best ( $z^j = 0$ ),

$$u_2^0 = m_2^j z^j; \quad (20)$$

What (20) says is that all graduates must be assured the same level of consumption in period 2, irrespective of the state of nature, and irrespective, also, of what happened in period 1. Therefore, the first-best  $z^j$  is an increasing function of  $m_2^j$ . Since, on average, science graduates have higher income than arts graduates, the first-best policy then re-distributes income from science to arts graduates.

In second best ( $z^j > 0$ ), the principal must take into account also the disincentive effect of  $z^j$  on study effort. Hence,  $z^j$  is decreasing in  $x^j$ . This may modify the first-best conclusion that science graduates must pay more than arts graduates. In first best,  $e^j$  is in fact lower for a than for s types. This is not necessarily true in second best. If, however, the effort level is lower for the arts type, and the marginal distributions of  $x^j$  are the same (in other words, greater effort has the same effect on the probability of getting high grades) for both types, it then follows

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<sup>16</sup>The trade-off between productivity and incentive costs is analyzed in Kim (1995) and Robbins and Sarath (1996).

that the expected  $x$  will be lower for the arty type.<sup>17</sup> Hence, period-2 consumption must be lower for the latter.

Since the second-best  $\zeta^j$  is increasing in  $m_2^j$ , and the second-best  $m_2^j$  is likely to be lower for  $a$  than for  $s$  types (because, for the same degree result, arts graduates have lower income on average, but also because arts students are induced to put in less effort, and will thus get lower degree results on average), it is unlikely that  $\zeta^j$  will be larger for the former than for the latter, but the opposite cannot be excluded a priori. In other words, arts graduate pay on average less than science graduates, but there is no reason why a highly successful arts graduates should be asked to pay less than an equally successful science graduate.

If the random components of the  $x$  vector are dependent and affiliated, the second-best  $\zeta^j$  is decreasing in  $x^j$ , but increasing in the other elements of  $x$ . Therefore, not only  $y^j$ , but also  $\zeta^j$ , should take account of  $j$ 's ranking in terms of degree result. By contrast, even if the random components of the vector  $m_2$  were not independent, the second-best  $\zeta^j$  would still depend on  $m_2^j$  only, because the marginal utility of  $j$ 's consumption does not depend on that of other people. A positive (negative) macroeconomic shock, bringing all graduate incomes up (down), should thus bring all the elements of  $\zeta$  up (down).

Let us now consider the possibility that the participation constraint is binding for some agents. As already pointed out, that will never happen in first best. It may be true in second best, however, because the cost to the principal of providing some agent with the incentive to study hard could outweigh the expected benefit of sending him to university. If the constraint is binding for anybody, that is likely to be the arty type, because these students have a lower expected period-2 income, for any given private cost, than the scientific type. That does not necessarily mean that arts graduates will have lower period-2 consumption than science graduates, however, because the authority will re-distribute in their favour. In second best, however, equality is not achieved (and, the higher the cost to the principal of providing arty students with the incentive to study hard, the further we shall be from equality). It could thus happen that the period-2 gain is not large enough to compensate the potential arts student for the period-1 loss from attending university. If that is the case, not all agents will (apply for a loan or scholarship to help them) go to university.

Let  $\tilde{\lambda}^j$  be the Lagrange multiplier associated with the participation constraint (9) for agent  $j$ . If the constraint is binding for agent  $j$ , the

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<sup>17</sup>Note that, due to our assumptions,  $x^j$  could be lower for the arty than for the scientific type even if  $e^j$  were higher for the former than for the latter.

l.h.s. of (13) becomes  $\frac{u_1^i(A^j=p^j)}{u_1^i(m_1^j+y^j_i x^j)}$ . As  $\Delta^j$  is positive, the second-best  $y^j$  is then larger than it would be otherwise. A similar argument applies to  $z^j$ . If the participation constraint is binding, the l.h.s. of (19) becomes  $\frac{u_2^i(A^j=p^j)}{u_2^i(w_2+m_2^j_i z^j)}$ . The second-best  $z^j$  is then smaller than it would be otherwise. If, as seems likely, the agent in question is of type a, the policy re-distributes even further in favour of these students. That is as one would have expected, because arts students gain less than science students from a university education.

We now come to the central question, whether the optimal (first or second best) policy is a loan or a scholarship scheme. Having found that, whether effort is observable or not, the period-2 payment required of agent  $j$ ,  $z^j$ , should be independent of the amount paid to him in period 1,  $y^j$ , we can conclude that  $y^j$  is not a loan, and that  $z^j$  cannot be construed to be a loan re-payment. In the first-best solution,  $y^j$  is effectively a personalized lump-sum subsidy, and  $z^j$  a personalized lump-sum tax. If effort were observable, the education authority would in fact know all there is to be known about potential students.<sup>18</sup> In the second-best solution (effort not observable),  $y^j$  may be interpreted as a scholarship conditional on both need and merit, and  $z^j$  as a tax conditional on income and merit. There is nothing to suggest that the optimal  $y^j$  is additively separable into two payments, one dependent on "need" ( $m_1^j$ ) only, and the other dependent on "merit" ( $x^j$ ) only.

Both the first and the second-best policy re-distribute from the relatively rich to the relatively poor (from students with high parental support to students with low parental support, from science graduates, who earn on average more, to arts graduates, who earn on average less). The second-best scheme re-distributes also from the less to the more academically successful. The second-best scholarship is in fact decreasing in parental support, and increasing in university results. The second-best graduate tax is increasing in graduate income, and decreasing in academic performance. Both the award of the scholarship, and the amount of the tax, are conditional on the agent taking a prescribed course of study (but this does not go against, if anything encourages, the student's predisposition). If the agent chooses otherwise, he will either not get the scholarship, or be charged a punitive tax.

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<sup>18</sup>Parental support, and aptitude for different types of study, are assumed known anyway.



## 4 Discussion

Our analysis started from the premise that, in the absence of full contingent markets, a number of young people who would have otherwise attended university education will not do so. It may thus be possible to increase social welfare by helping these young persons to attend university. The question is how. Loans give students every incentive to apply themselves, but distort choice towards subjects with a higher earning potential; they are also unfair to students from poor families. Scholarships do not distort choice, but give rise to a moral hazard problem in that students of subjects with limited earning potential may be tempted to shirk. If they are financed out of general taxation, scholarships may also be unfair to non graduates.

Our answer is that potential university students with the right characteristics (such that they would choose to attend university in the presence of full contingent markets) should be offered a scholarship dependent on both "need" (parental support) and "merit" (academic performance). The scheme should be financed by a graduate tax designed so as to re-distribute income from the better paid, to the academically more successful (as well as from students coming from richer family to students coming from poor ones).

The award of a scholarship should be conditional on the choice of university degree (those who choose to do otherwise should be denied a scholarship, or charged a punitive tax). But students with a natural aptitude for studies that do not hold the prospect of a well paid job ("arts") should not be pushed towards potentially more lucrative studies ("science"). Combined with the proposition that, other things being equal, better paid graduates should be taxed more than low paid ones, this implies some degree of cross-financing of arts studies.

If effort were observable, students should be required to take the very type of degree that they would have chosen, in the presence of full contingent markets. Since study effort is not observable, the choice of subject mix should be distorted. In the absence of either perfect contingent markets, or government policy, there would be two kinds of distortion. First, some who could have benefited from going to university would not do so. Second, those who would go to university would choose a more scientific mix of subjects than is efficient. The second-best policy pushes in the opposite direction, in the sense that it requires arts students to specialize in their preferred subjects even further than they would have done otherwise. That is because pushing such students into taking more arts subjects makes studying "easier" (less costly, more pleasurable) for them, and it thus reduces the cost to the education authority of providing them with the incentive to study hard. In second best, not all those

who could have benefited from a university education will necessarily do so.

The finding that second-best scholarships and graduate taxes should depend on academic performance gives rise to a practical issue that we have not discussed so far. If the education authority could observe only annual degree results, our finding would imply that at least part (perhaps a large part) of the award should be paid on graduation only. That would be a problem, because we are assuming that students cannot support themselves by borrowing. Fortunately, however, partial results are generally available at fairly frequent intervals, such as the quarter or the year. The scholarship can then be paid in installments, and the total amount adjusted quarterly or yearly as the examination record builds up.

If the random components of the university results of different agents are related in the technical sense explained in the text, the second-best scholarship that a person receives as a student, and the second-best tax that he will have to pay as a graduate, take account not only of his own degree result, but also of those of other students. An implication, if the correlation is positive, is that an (upward) grade drift should not fool the education authority into giving every student a higher scholarship, or charging every graduate a lower tax. By contrast, even if the random components of graduate incomes were positively correlated, the second-best tax payable by a graduate takes only account of his income, and not also of the incomes of others. The reason for this asymmetry is that income comparisons do not convey information, additional to that already provided by grade comparisons, on the amount of study effort that a person put in as a student.<sup>19</sup>

Having established that the amount of money a person should optimally pay as a graduate does not depend on the amount of public money received as a student, the latter cannot be interpreted as a loan, or the former as a loan re-payment. Any direct link between individual payments and receipts would in fact impose an unnecessary constraint on the design of policy. Even a loose link, as envisaged in an income contingent loan scheme, does not appear to be justified on theoretical grounds. There is, furthermore, nothing in the analytical results to suggest that the optimal policy could be run as two parallel schemes, one awarding "student grants" on the basis of "need" (lack of parental sup-

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<sup>19</sup>That is strictly true, however, only because we are assumed that the probability of a high income depends only on degree type, and degree result. Income comparisons would be relevant, in determining the level of the tax, if we allowed for the fact that income depends not only on qualifications, but also on effort in finding and keeping a good job.

port), and the other awarding "scholarships" on the basis of "merit" (academic performance):

Our analysis presupposes the existence of a school system which makes it possible for every child to reveal his natural talent, and his aptitude for different types of studies. Therefore, our conclusions do not apply with equal force to an institutional setting where school attendance (or access to good schools) is restricted by ability to pay, or where premature specialization may prevent individual characteristics from being revealed to the full.

## 5 Appendix

In this Appendix we briefly examine the consequences of the assumption of affiliated random variables on the form of the likelihood ratio  $\frac{f_{e^j}}{f}$ : A full discussion of this topic is in Luporini (2002).

Following the standard approach (Mirrlees, 1974), we have treated the final degree results,  $x^j$ , as random variables with joint density  $f(x; e)$ , parameterized by the vector of agents' efforts,  $e$ : In other words, we have implicitly assumed that, given a certain level of effort, the result is affected by a random component. Alternatively, we could consider  $x^j$  as a function,  $x^j = x_j(e^j; \mu^j)$ , of both effort,  $e^j$ , and a random variable,  $\mu^j$ , representing the influence of luck on university results: Let  $x^j$  be monotonically increasing in both  $e^j$  and  $\mu^j$ : Let  $\mu = \mu^j$ . If we assume that the elements of  $\mu$  have joint density  $g(\mu)$ ,  $f(x; e)$  becomes the transformation obtained from  $g$  via the functions  $x_j$ .

Assume that the elements of  $\mu$  are affiliated, non-independent random variables. For simplicity, we consider a bivariate case where  $j = A; B$ , but definitions and results generalize to multivariate random variables. A bivariate random variable  $\mu^A; \mu^B$  is said to be affiliated (Milgrom and Weber, 1982; Tong, 1980) if

$$g(\bar{\mu}^A; \bar{\mu}^B) g(\underline{\mu}^A; \underline{\mu}^B) \geq g(\bar{\mu}^A; \underline{\mu}^B) g(\underline{\mu}^A; \bar{\mu}^B) \quad \text{if } \bar{\mu}^A > \underline{\mu}^A \text{ and } \bar{\mu}^B > \underline{\mu}^B: \quad (21)$$

Affiliation broadly means that the random variables tend to move together, i.e. that a high realization of  $\mu^A$  is more likely in the case of a high than in the case of a low realization of  $\mu^B$ . Note that independent random variables are affiliated since, in that case, (21) always holds as an equation.

Consider now (13) for agent A (the same argument obviously holds for agent B). We can write

$$\frac{f_{e^A}(x^A; x^B; e^A; e^B)}{f(x^A; x^B; e^A; e^B)} = \frac{g_1(x_A^{i-1}(x^A; e^A); x_B^{i-1}(x^B; e^B))}{g(x_A^{i-1}(x^A; e^A); x_B^{i-1}(x^B; e^B))} \frac{\partial x_A^{i-1}(x^A; e^A)}{\partial e^A}; \quad (22)$$

where  $\frac{\partial x_A^{i-1}(x^A; e^A)}{\partial e^A} < 0$ : As a consequence, for  $\frac{f_{e^A}(x^A; x^B; e^A; e^B)}{f(x^A; x^B; e^A; e^B)}$  to be decreasing in  $x^B$ ,  $\frac{g_1(x_A^{i-1}(x^A; e^A); x_B^{i-1}(x^B; e^B))}{g(x_A^{i-1}(x^A; e^A); x_B^{i-1}(x^B; e^B))}$  must be increasing in  $x_B^{i-1}$ :

Note that, for any  $\bar{\mu}^A > \mu^A$ ,

$$\frac{g_1(\bar{\mu}^A; \mu^B)}{g(\bar{\mu}^A; \mu^B)} = \exp \int_{\mu^A}^{\bar{\mu}^A} \frac{g_1(\mu^A; \mu^B)}{g(\mu^A; \mu^B)} d\mu^A;$$

Therefore, (21) implies that  $\frac{g_1(\mu^A; \mu^B)}{g(\mu^A; \mu^B)}$  is increasing in  $\mu^k$ .

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